749

VOLUME 81 PAPER No. 749

PROCEEDINGS

AMERICAN SOCIETY OF CIVIL ENGINEERS

JULY, 1955

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

THE ROLE OF THE SANITARY ENGINEER IN THE NUCLEAR ENERGY PROGRAM

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SANITARY ENGINEERING DIVISION

(Discussion open until November 1, 1955)

Headquarters of the Society
33 W. 39th St.
New York 18, N. Y.

PRICE $0.50 PER COPY

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This paper was published at 1745 S. State Street, Ann Arbor, Mich., by the American Society of Civil Engineers. Editorial and General Offices are at 33 West Thirty-ninth Street, New York 18, N. Y.

THE ROLE OF THE SANITARY ENGINEER IN THE NUCLEAR ENERGY PROGRAM*

Roy J. Morton,** M. ASCE

INTRODUCTION

Like engineers in other branches of the profession, those engaged in sanitary engineering are increasingly concerned with the problems and the implications of the nuclear energy program. Technological and industrial developments in the field of nuclear energy during the past ten years have brought with them new health problems and potential hazards and have added to the complexity of existing problems. The range of these problems is very broad and involves practically all branches of public health activity. However, from the very nature of nuclear energy operations and phenomena, the protection of people against ionizing radiation must be based largely upon control of the environment. Therefore, many aspects of radiation control are within the special field of sanitary engineering.

From the inception of the atomic energy program the potential hazards associated with this new industry, particularly in the disposal of its waste by-products, have been recognized. Under the authorization and policy of the Atomic Energy Commission, high standards of protection against these hazards have been established and maintained even when expensive emergency measures were required in order to do so.(1) The costs of health and safety measures in the nuclear energy program and the reasons why they are high were discussed in 1950 in an AEC report(1) and in a technical journal.(2) At best, radiation protection promises to remain costly but with time and advancing knowledge present costs may be further reduced. An essential job of the sanitary engineer is to cooperate with the scientists, engineers, and executives who have "grown up" with this industry in order to develop more permanent and economical methods for the sanitary control of radioactive materials in the environment.

The purpose of this paper is: 1) to discuss briefly the functions of sanitary engineers in relation to the nuclear energy program; 2) to review the problems of control of environmental exposures to ionizing radiation, particularly in the handling and disposal of radioactive wastes; and 3) to consider the challenge and the opportunity for sanitary engineers to participate in the development and utilization of nuclear energy.

The Sanitary Engineer and His Functions

The functions and qualifications of sanitary engineers have been defined and discussed by committees of various engineering, public health, and

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* Presented at Polytechnic Institute of Brooklyn, Centennial Symposium, "Some Aspects of Civil Engineering in the Atomic Age," November 20, 1954.

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educational organizations. A statement prepared in 1943 under the auspices of a committee of the National Research Council still provides a good general definition of the sanitary engineer and his requisite abilities.(3) A part of this statement is as follows:

"The professional occupational designation 'sanitary engineer' shall apply to a graduate of an approved scientific or engineering school who has fitted himself by suitable training, or study, and by experience to conceive, design, construct, operate, direct, and manage engineering works developed, as a whole or in part, a) for the protection and promotion of the public health or b) so as to be capable of insuring the public health.

"The ability to identify, evaluate, and explain, in terms of their sanitary or public health implications, those factors connected with engineering works that will prevent injury to health or that will promote health, in addition to the ability to conceive, design, construct, operate, direct, and manage such works, shall constitute the basis of differentiation between individuals qualified as sanitary engineers and individuals qualified only as civil, mechanical, electrical, mining, or chemical engineers."

Interest of Sanitary Engineers in Nuclear Energy

It is significant and encouraging that an increasing number of workers, teachers, and students in sanitary engineering and associated fields are seriously interested and engaged in the nuclear energy program. For a number of reasons, however, it has been difficult to develop satisfactory programs through which health departments and other agencies not connected with the Atomic Energy Commission can participate fully in efforts to resolve the public health problems of nuclear energy. This field is new and unique in many respects and is still relatively unfamiliar, even to those in the technical professions. The Atomic Energy Act does not specifically recognize the responsibility and authority of federal, state, and local health agencies and therefore the basis for their official cooperation in the program is indefinite. The necessary secrecy limitations for national security have limited the free exchanges of information and discussion which are essential in a complex developmental program. Consequently, most of the state health departments and other health agencies do not yet have the trained personnel, experience, or active programs of investigation and control that are necessary to deal adequately with the sanitary engineering problems of nuclear energy. It is more and more apparent, however, that the expansion of nuclear energy operations necessitates a broad program of health protection into which the established precedents of sanitation and public health practice must be integrated.

The concern of health officers, water works officials, and sanitary engineers with the problems of nuclear energy has been accentuated by the passage of the Atomic Energy Act of 1954. A stated purpose of this act is to "encourage widespread participation in the development and utilization of nuclear energy for peaceful purposes." If the expected increase in the size and geographical spread of the nuclear energy industry is realized, the scope and the technical and administrative difficulty of the attendant health problems will be correspondingly increased. Therefore, the sanitary engineer who has been accustomed to consider industrial and environmental problems in terms of bacterial, chemical, and general physical factors must broaden his viewpoint to include radioactivity. This calls for a better understanding of the field of nuclear energy and familiarity with its terms, units and standards.

The health hazards from radioactive materials are due to the fact that the nuclei of the atoms which are unstable tend sooner or later to give off ionizing radiation - particles or rays of high energy. The radiation is able to penetrate matter to a greater or less degree and may have detrimental effects upon living tissue. Parts or all of the human body may be affected either by external radiation or from exposure to radioactive materials taken into the body. People are exposed continually to a low level of radiation from cosmic rays and from the natural radioactive materials contained normally in the human body and in soil; and occasionally higher exposures occur as from diagnostic x-rays or other sources. The objective in radiation protection is to prevent any exposure which might cause undesirable effects when added to the radiation to which people are ordinarily subjected.

In general, the role of the sanitary engineer in relation to the control of ionizing radiation is to appraise the extent of exposure through environmental factors such as water, food, soil, or direct contact with radioactive contaminants; and to aid in developing and applying measures which will assure that the levels of exposure are kept within the accepted permissible limits.

Sanitary engineering activities in the Atomic Energy Commission and in Commission-sponsored projects have been discussed by Lieberman,[4] and in the 8th Semi-Annual Report of the Atomic Energy Commission.[1] A very good discussion of the quantitative limits of permissible external and internal exposure of persons to radiation and the factors determining radiation damage to man was presented by Morgan in 1951.[5] Acceptable standards for the maximum permissible amounts of radioisotopes in the human body and maximum permissible concentrations in air and water have been the subject of much study and of a published report in 1953 by the Subcommittee on Permissible Internal Dose, National Committee on Radiation Protection of the National Bureau of Standards.[6]

Waste Disposal Problems

One of the very urgent problems in the development and utilization of nuclear energy is the safe and economical handling and disposal of radioactive wastes. The production, processing, and use of radioactive materials may produce liquid, solid, or gaseous radioactive wastes. These wastes vary widely in chemical composition and in the kinds and amounts of radioactive materials they contain. Occasionally, harmful chemical substances may be present but usually the essential problem is to separate and retain enough of the radioactive contaminants so as to reduce the remaining radioactivity to a safe level for the particular method of disposal. The high costs of the methods now available for separation and retention of the fission products and other radioactive constituents of reactor process wastes are a major item in nuclear energy operations. Much further study and improvement of the methods of waste disposal are essential for the full development and use of nuclear energy.

Foremost in the thinking and planning for the utilization of nuclear energy is the prospective development of feasible central station nuclear power plants and the evolution of a widespread nuclear power industry. Some of the problems of nuclear power development are to be discussed by another speaker during this symposium. From the viewpoint of the control and disposal of radioactive wastes, the development of industrial nuclear power will present many perplexing problems, and potential hazards of much greater significance than have been dealt with in the past.

The potential hazards of radioactive wastes are largely those of internal exposure due to inhalation or ingestion of radioisotopes in contaminated air, water or food the control of which is traditionally of concern to the sanitary engineer. The principles of control of radioactive contaminants are essentially the same as have been applied successfully in the past in connection with other major operations and new fields of activity. Particularly in the problems of waste disposal, industrial hygiene, and water pollution control in the nuclear energy program there is a definite parallelism with the problems arising from other developments such as the chemical, metallurgical, and drug industries.

In approaching such problems the sanitary engineer must take into account the properties peculiar to the materials produced or used, the manner and extent of exposure of people, and the harmful effects that may result. Usually he must consider also other possible effects, such as economic damage, harm to plant and animal life, or interference with essential activities. Practicable methods must be selected or developed for keeping human exposures always within permissible limits under unusual as well as normal circumstances. In the field of nuclear energy as in other sanitary engineering activities many related specialities of science and engineering are involved and must be coordinated in order to develop an effective overall program.

Uncertainties in Evaluation of Environmental Hazards

Dilution in air or water and seepage into the soil are commonly used in the disposal of sewage and industrial waste effluents. In the disposal of radioactive wastes the time element, that is holdup for radioactive decay, is important if short-lived radioisotopes are involved. Upon first thought it might appear that simple calculations of dilution, decay, and other relationships would indicate for a particular situation the amounts of radioactive wastes that could be disposed of by these methods without exceeding the permissible concentrations in water, air, or soil. The problem is complicated, however, by numerous physical, chemical, and biological factors which influence the dispersal and the behavior of radioactive elements in the natural environment. Mention of a few of these factors will serve to illustrate the uncertainties which necessitate extreme caution and large factors of safety in the release of radioactive contaminants.

Nature frequently shows remarkable abilities to concentrate various chemical elements particularly when they are present in trace amounts as is the case with most of the radioisotopes. Many plants, small animals, and the microscopic organisms have been found to build up in their bodies concentrations of radioisotopes many hundreds and in some cases thousands of times the concentration present in the water or soil in which they grow. Much further research and field studies are required in order to learn more definitely the mechanisms involved, the rapidity of build-up of radioisotopes, the maximum concentrations which may be expected under various conditions, the transfer of concentrated activity through biological food chains, and the fate of the radioactive materials after death and decay of the organisms.

Experiments and field sampling have shown that clays and other soil materials have adsorptive and ion exchange properties which enable them to retain and concentrate many of the radioisotopes. This is of interest in the disposal of liquid wastes since the suspended turbidity in a stream or lake may change the distribution of radioactive materials in the water and upon settling may cause an increase of radioactivity in the bottom sediments. The ability of certain types of soils to adsorb and fix radioisotopes is also of interest in relation to underground disposal of radioactive wastes by burial or seepage.

The degree and permanency of fixation of the radioisotopes upon natural soil particles are critical factors in considering the distance that radioactive wastes might travel underground and the potential hazards that might result in different soil formations.

Many other enviromental influences are of importance in evaluating the health problems of radioactive waste disposal. In rivers and lakes hydraulic and hydrologic factors must be considered. These include variations in stream flow, incomplete mixing due to streaming and stratification of portions of the water, bottom deposition and later relocation of sediments, and the time of water travel which affect the reduction of radioactivity in the water by dilution, adsorption and radioactive decay. Meteorological conditions affect the diffusion and dilution of airborne contaminants into the atmosphere; and much more data are needed on the washing-out of atmospheric contaminants by rainfall. The extent to which animals, such as fish and waterfowl, can concentrate the more dangerous radioisotopes in edible portions of their bodies under natural conditions must be defined in order to appraise the possibility of eating contaminated foods. The concentration and distribution of radioactive materials in waste drainage systems and in water and sewage treatment plants are of particular interest to sanitary engineers and have been studied extensively during the past several years.

The Search for Methods of Ultimate Disposal of Liquid Radioactive Wastes

The problems of final disposition of liquid radioactive wastes, or of solids that might be redissolved, have been the subject of much study and discussion but they are still unsolved. The nature and the implications of these problems from the viewpoint of the sanitary engineer have been discussed in an article by Hatch.[7] This article points out that the present practice of storing large volumes of radioactive liquid wastes in metal tanks has been considered a temporary expedient; and that this method would be uneconomical and impractical in a large scale development of nuclear energy for peace-time uses. The relative advantages and limitations of storage tank systems as compared with the dispersal of wastes, as in the ocean or in the ground, are outlined in some detail.

The available methods for the final disposal of wastes are not numerous. They include dilution in streams, lakes, or the ocean; deposit in soil pits or in deep underground formations where they will be retained for a sufficient length of time; sealing of liquids or solids in heavy artifical containers and sinking into the depths of the oceans; discharge and dilution of gases to the atmosphere; segregation and recovery of useful by-products at the source; and storage in tanks on land with whatever permanency and factors of safety that can be designed and built into the tanks.

The criteria for ultimate disposal of liquid ratioactive wastes will be influenced in many respects by the development of a large, widely-distributed nuclear power industry. Three considerations will be mentioned.

1) Economy. - In order to be competetive in cost with other sources of power there will be pressure to explore every possible means of waste disposal that might be acceptable but less costly than storage in tanks of concrete and steel.
2) Permanency of Retention. - The quantities of fission products produced by a sizable power industry will be so great that the wisdom of dispersal of the wastes to the environment (as in the ocean) even under the most ideal conditions will be open to serious questions, and a long range policy of dispersal should not be adopted except under the most carefully planned and controlled conditions.[7] Therefore it seems necessary to

develop better and cheaper methods of local retention of the wastes for long periods of time.

3) Definition of Conditions and Potential Hazards. - Whatever the method or variety of methods of local retention that may be developed and adopted, a very extensive program of fundamental and practical studies to define the extent of the possible hazards from the wastes and their effects under various conditions will be necessary.

One example of the types of studies that are pertinent to the disposal of liquid wastes from power reactors are the investigations of especially located and constructed waste pits which have been initiated at the Oak Ridge National Laboratory. The aim of these studies is to: 1) evaluate and take advantage of the adsorptive capacity of large clay soil formations (in this case a deep bed of shale); 2) retain the bulk of the radioactive constituents of liquid wastes within the waste pit itself; 3) retain any radioactive materials that might seep away by adsorption in the soil within a short distance of the pit; 4) evaluate the behavior and interaction of the soil, the groundwater, the radioactive materials, and the non-radioactive chemicals in the wastes as a basis for judging the maximum distance of travel and the levels of contamination that might be expected; and 5) develop feasible monitoring techniques for operation and control measurements. Laboratory results in the soil studies have thus far been encouraging. Field investigations obviously require the collaboration of specialists in geology, hydrology, and soil sciences and data on these aspects are being collected and studied.

Sanitary Engineering Participation and Leadership

The sanitary engineering profession has a responsibility to move rapidly and effectively in relation to the nuclear energy program, particularly in the study and solution of the problems of radioactive wastes. In doing so it is essential that the overall approach and the performance of individuals shall be based upon sound and thorough understanding and application of well-known sanitary engineering principles. To participate in the field of nuclear energy the sanitary engineer must learn new relationships and techniques. His ability to apply this knowledge constructively and distinctively depends upon his basic training and experience as a sanitary engineer. He must attack the problems of nuclear energy in the light of - not in spite of - his engineering training and objectives.

One great difficulty is the speed of development and the rapidity of change in the nuclear energy industry. In order to meet the present and the prospectively greater need for sanitary engineering guidance and leadership, particularly with respect to the long range implications of waste disposal methods and policies, the numbers of sanitary engineers who have developed competency and the extent of their participation in this field should be greatly increased and as rapidly as possible. Those employed in general practice, as in health department programs, must be familiar with the criteria of evaluation and methods of control of the occasional radiation problems which they may encounter. A small number of sanitary engineers should prepare themselves as specialists for research and development, teaching and other major responsibilities in the field of nuclear energy.

Much progress has been made since the AEC-sponsored Seminar on Radioactive Wastes in Washington, D. C., January 1949 - less than 6 years ago. This was the first assembly of a representative group of the sanitary engineers of the country with specialists in the field of nuclear energy. In the

concluding session of the seminar Abel Wolman commented on sanitary engineering problems and responsibilities as follows:(8)

"It is likely that the development of this industry for peacetime purposes will spread geographically and therefore as time goes on will have a potential impact in one direction or another on a wider and larger population group. - - - - - The sanitary engineer should and will extend his normal responsibilities into this particular area of industrial and research operations.

The record since 1949 shows the accuracy of Wolman's prediction. In the meantime through research and development, much has been done to improve basic knowledge regarding the technical aspects of nuclear problems and potential hazards as they have appeared up to the present time.

Attention also is being given to the administrative problems involved in the assumption of increased responsibility by public health agencies. Within the past five years the U. S. Public Health Service and a number of state health departments have established programs of radiological health which are active in training, investigations, and service functions. During October of this year the American Public Health Association and the Sanitary Engineering Division of the American Society of Civil Engineers both passed resolutions concerning the nuclear energy program. One resolution was aimed to encourage the training and the employment in health agencies of competent radiological health personnel. The other requested recognition in the Atomic Energy Act of the role of federal, state, and local health agencies in the protection of health as a part of the long range nuclear energy program.

Some health officers and their engineers have seemed to be afraid to accept responsibility and become active in the field of nuclear energy because they have felt that their knowledge and experience are inadequate. The sanitary engineer who may be faced with these problems must not be over-awed by their novelty and difficulty nor be diverted by the idea that he must become a nuclear physicist before he can attack them. The complexity and technical difficulty of nuclear physics, radiochemistry, and radiobiology are truly awe-inspiring. The same may be said, however, with regard to the other special branches of biology, or chemistry, or physics which provide the scientific basis for sanitary engineering practice. The engineer cannot hope to have a comprehensive knowledge of all the basic sciences. He should be familiar with the essential for his work and be able to obtain, interpret, and apply specialized information when necessary. An increasing number of sanitary engineers are becoming informed regarding nuclear energy and a body of literature dealing particularly with the evaluation and control of the health problems of radiation control is developing rapidly.

It must be recognized that the aims of sanitary engineering and the special abilities of sanitary engineers may not be fully understood by those who are directly responsible for the concept, design, and operation of nuclear energy projects. Unless sanitary engineers are prepared for work in this field and are properly integrated into the nuclear energy program, fundamental principles of sanitation may be overlooked or disregarded until serious hazards have developed. Adequate corrective measures will then be difficult and costly and in some cases may be impossible.

In conclusion, it may be pointed out that the same lack of understanding has been encountered and dealt with in the past in the familiar fields of community, muncipal and industrial sanitation. The methods by which sanitary engineers have gained recognition and responsibility in these other fields

have included: research and the improvment of knowledge of environmental hazards; the standardization of measurements of environmental conditions; development and demonstration of successful methods and systems of sanitary control; education of sanitary engineers, of other professions, and of the public; and courageous leadership in the establishment of sound administrative control programs. These are likewise the elements of a coordinated sanitary engineering approach in the field of nuclear energy.

REFERENCES

1. Atomic Energy Commission, "Control of Radiation Hazards in the Atomic Energy Program," 8th Semi-Annual Report (July 1950), Page 98 et seq., U. S. Government Printing Office.

2. "Costs of Radiation Protection," Nucleonics 7: 3, 73-76 (Sept. 1950).

3. "Criteria for Determination of Essential Sanitary Engineers in Public Health Services," Sewage Works Jour., 15: 746-748, (July, 1943).

4. Lieberman, J. A., "Sanitary Engineering Activities in the Atomic Energy Commission," American Society of Civil Engineers, Sanitary Engineering Div., New Orleans Convention, March 5-7, 1952, Preprint paper no. 17.

5. Morgan, K. Z., "Quantitative Limits of Permissible Exposure of Personnel (External and Internal)," Lectures presented at the In-Service Training Course in Radiological Health, Univ. of Michigan, School of Public Health, Ann Arbor, Michigan, Feb. 5-8, 1951, pages 67-76.

6. National Bureau of Standards, "Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water," Hand Book 52, Issued March 20, 1953, U. S. Government Printing Office.

7. Hatch, L. P., "Ultimate Disposal of Radioactive Wastes," American Scientist, 41: 410-421 (July 1953).

8. "Digest of Proceedings, Seminar on the Disposal of Radioactive Wastes," Sponsored by the U. S. Atomic Energy Commission, January 24-25, 1949. Washington, D. C. (USAEC mimeographed).

PROCEEDINGS PAPERS

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